Sub Surface Production Tools

1. Tubing

Tubing is a string of steel pipes run inside the casing to provide a conduit for reservoir fluids to flow from the producing formation to the surface**.**

Components

1. Tubing Body

- Main pipe section of the tubing string.
- Carries oil, gas, and water from the reservoir to the surface.
- Designed to withstand high pressure and temperature.

2. Coupling

- Short threaded connector joining two tubing joints.
- Provides a leak-proof connection.
- Maintains the mechanical strength of the tubing string.

3. Threaded Connections

- Machined threads at tubing ends.
- Allow assembly of multiple tubing joints.
- Prevent fluid leakage under high pressure**.**

4. Internal Bore

- Hollow central passage inside the tubing.
- Allows production fluids to flow to the surface

Figure 1 TUBING

Function

- Provides a dedicated flow path for oil, gas, and water from the reservoir to the surface.
- Protects the casing from corrosion, erosion, and high-pressure production fluids.
- Serves as the main conduit for production operations.
- Allows installation of downhole completion equipment such as packers, gas lift valves, safety valves, and pumps.
- Facilitates well interventions and workover operations.
- Helps maintain production efficiency by minimizing pressure losses.
- Provides a controlled environment for fluid flow and production management.

Working Principle

- Tubing is run inside the casing from the surface to the producing zone.
- Reservoir fluids enter the wellbore through perforations made in the casing.
- The fluids flow into the tubing due to reservoir pressure or artificial lift mechanisms.
- Since tubing has a smaller diameter than casing, it provides a more efficient and controlled flow path.
- Production fluids are transported through the tubing to the wellhead and surface facilities.
- Surface valves regulate pressure and flow rates during production.
- The tubing string withstands high pressures, temperatures, and mechanical loads throughout the well's life.

2. Hydraulic Packer

A hydraulic packer is a downhole sealing device that is set using hydraulic pressure to isolate the annular space between the tubing and casing.

Main Components

1. Mandrel

- Main structural body of the packer.
- Supports all other packer components.
- Allows fluid passage through its central bore.

2. Packing Element

- Made of rubber or elastomer.
- Expands against the casing wall during setting.
- Creates the pressure-tight seal.

3. Hydraulic Piston

- Activated by tubing pressure.
- Converts hydraulic force into mechanical movement.
- Initiates packer setting.

4. Slips

- Hardened steel gripping elements.
- Anchor the packer to the casing wall.
- Prevent packer movement.

5. Cone

- Tapered component behind slips.
- Pushes slips outward during setting.

6. Lock Ring

- Locks the packer in the set position.
- Prevents accidental release.

7. Bypass Valve

- Equalizes pressure during retrieval.

- Facilitates safe packer removal.

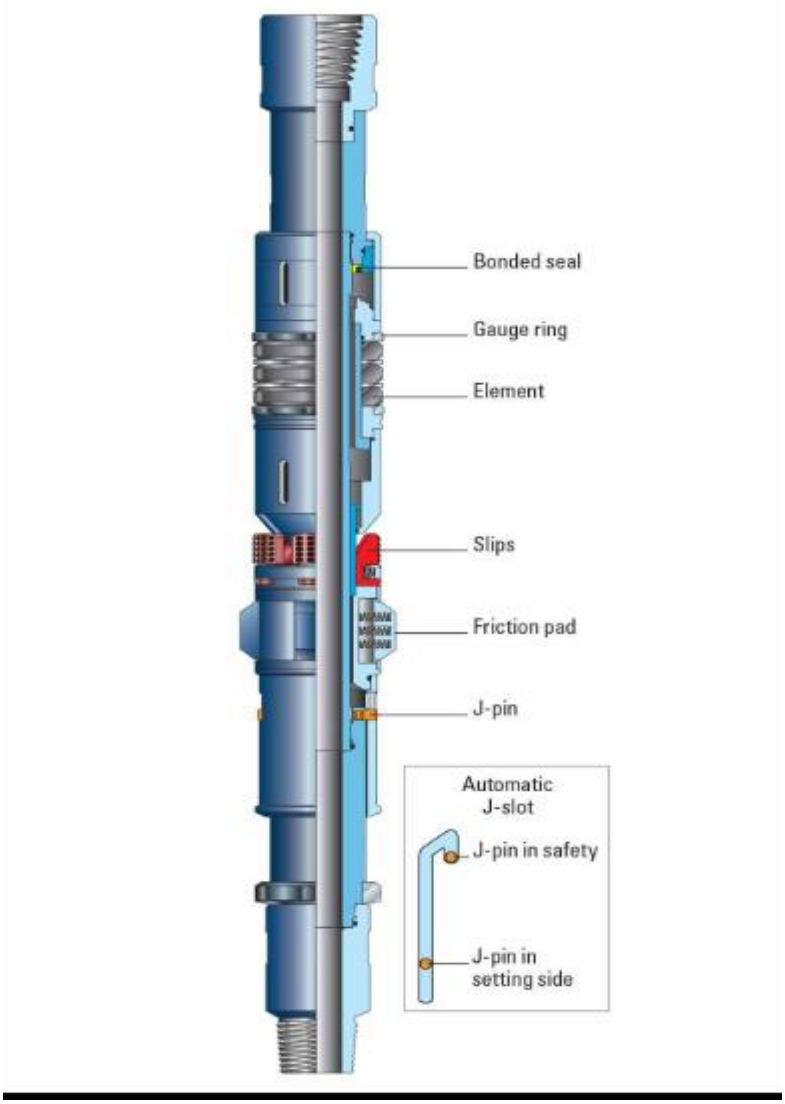

Figure 2 Hydraulic Packer

Function

- Provides a pressure-tight seal between the tubing and casing.

- Isolates producing formations from each other.
- Prevents fluid communication between different reservoir zones.
- Directs all production through the tubing string.
- Supports tubing weight and reduces tubing movement.
- Improves efficiency of gas lift and injection operations.
- Protects the casing from excessive pressure exposure.

Working Principle

- The packer is installed as part of the tubing string and lowered to the desired depth.
- Hydraulic pressure is applied through the tubing from the surface.
- The pressure acts on an internal piston mechanism.
- The piston forces slip outward to grip the casing wall.
- Simultaneously, elastomeric sealing elements are compressed.
- The sealing elements expand radially and contact the casing wall.
- A strong seal is formed that prevents fluid movement through the annulus.
- Once set, the packer remains locked until a specific release procedure is performed.
- The packer can withstand high differential pressures during production and injection.

3. Mechanical Packer

A mechanical packer is a downhole sealing device that is set by tubing movement, such as rotation, tension, or compression.

Main Components

1. Mandrel

- Main body of the packer.
- Provides structural support.

2. Packing Element

- Rubber sealing component.
- Expands against casing to isolate zones.

3. Slips

- Grip the casing wall.
- Anchor the packer securely.

4. Cone Assembly

- Forces slips outward.
- Assists packer anchoring.

5. J-Slot Mechanism

- Controls setting and release operations.
- Activated by tubing movement.

6. Drag Blocks

- Create friction with casing.
- Help maintain the packer position during setting**.**

7. Lock Ring

- Holds the packer in the set condition.

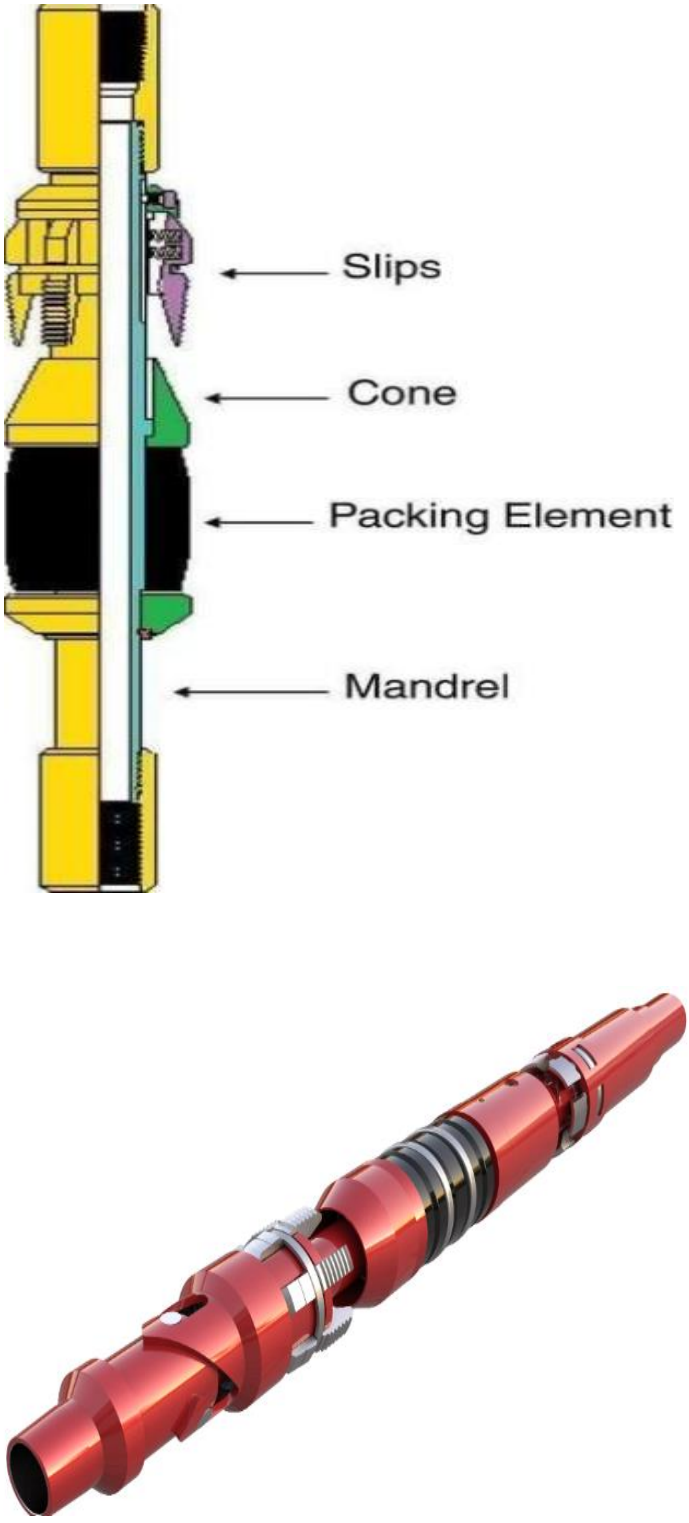

Figure 3 Mechanical Packer

Function

- Creates an effective seal between tubing and casing.
- Provides zonal isolation during production and stimulation operations.
- Prevents unwanted fluid migration between formations.
- Maintains pressure integrity in the well.
- Supports the tubing string within the well.
- Improves efficiency of production and injection operations.
- Used in wells where a hydraulic setting is not required.

Working Principle

- The packer is lowered into the well along with the tubing string.
- Once the desired depth is reached, tubing movement activates the setting mechanism.
- Setting may be achieved by tubing rotation, compression, tension, or a combination of these actions.
- Slips move outward and anchor the packer to the casing wall.
- Rubber sealing elements are compressed and expand against the casing.
- The expanded sealing elements create a pressure-tight barrier.
- The packer remains securely set during production.
- Retrieval is achieved by applying a specific tubing movement to release the locking mechanism.
- Mechanical packers are simple, reliable, and commonly used in production wells.

4. Gas Lift Valve (GLV)

A Gas Lift Valve is a pressure-operated valve that injects high-pressure gas from the annulus into the tubing to assist fluid production.

Main Components

1. Valve Body

- Main housing of the valve.
- Protects internal components.

2. Bellows

- Flexible metallic chamber.
- Contains nitrogen charge.
- Senses pressure changes.

3. Nitrogen Charge Chamber

- Filled with pressurized nitrogen.
- Controls valve opening and closing pressure**.**

4. Valve Stem

- Moving component connected to the bellows.
- Opens and closes the gas flow path.

5. Valve Seat

- Sealing surface for the valve stem.
- Prevents gas leakage when closed.

6. Orifice Port

- Opening through which gas enters the tubing.
- Controls gas injection rate.

7. Check Valve

- Prevents reverse flow of fluids.
- Protects the gas lift system.

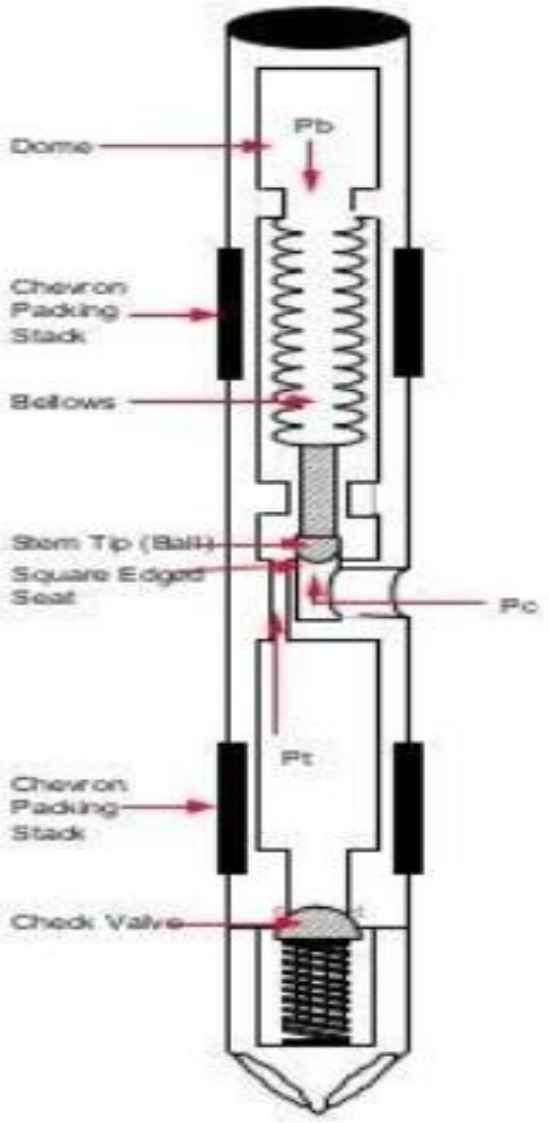
Dome
Pb
Chevron
Packing
Stack
Bellows
Stem Tip (Ball)
Square Edged
Seat
Pc
Pt
Chevron
Packing
Stack
Check Valve

Figure 4 GLV

Function

- Injects compressed gas from the annulus into the production tubing.
- Assists fluid lifting in wells with insufficient natural reservoir energy.
- Reduces the density of the fluid column inside the tubing.
- Lowers bottom-hole flowing pressure.
- Increases production rates from mature wells.
- Extends the productive life of oil wells.
- Enables continuous or intermittent gas lift operations.

Working Principle

- High-pressure gas is injected from the surface into the annular space.
- The gas travels downward through the annulus toward the gas lift valve.
- When annulus pressure exceeds the valve opening pressure, the valve opens.
- Gas enters the tubing through the valve ports.
- The injected gas mixes with produced fluids inside the tubing.
- This reduces the overall density of the fluid column.
- Reduced hydrostatic pressure allows reservoir fluids to flow more easily.
- The lighter fluid mixture rises toward the surface.
- When annulus pressure decreases below the closing pressure, the valve closes automatically.
- The process continues throughout the production period.

5. Mandrel

A mandrel is a special tubing component used to hold and position downhole equipment, particularly gas lift valves, at specific depths within a well.

1. Mandrel Body

- Main tubular structure of the mandrel.
- Provides mechanical strength and pressure containment.

2. Internal Bore

- Central passage through the mandrel.
- Allows fluid flow through the tubing string.

3. Threaded Connections

- Located at both ends of the mandrel.
- Connect the mandrel to other tubing sections.

4. Seal Bore

- Precision-machined surface.
- Provides a sealing area for downhole tools and accessories.

5. Ports (if applicable)

- Openings that allow fluid or gas communication.
- Commonly found in gas lift mandrels.

6. Equipment Housing Section

- Area designed to accommodate valves or other completion equipment.
- Supports and protects the installed device.

7. Locking/Profile Section

- Provides a secure location for locking downhole equipment.
- Prevents movement during operation.

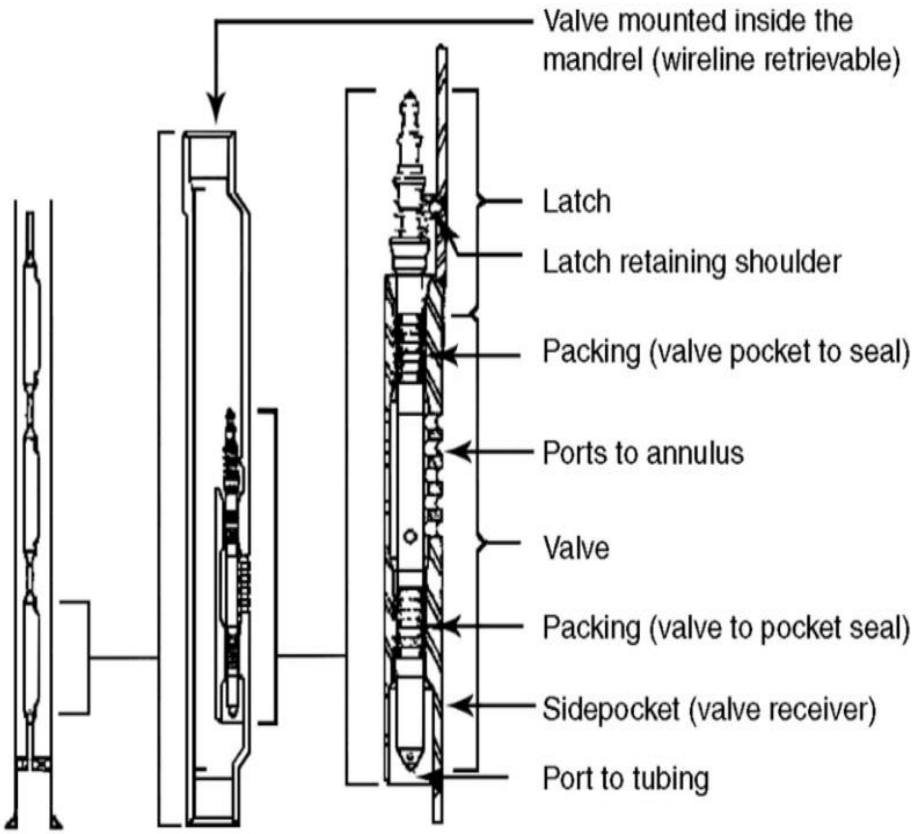

Figure 5 Mandrel

Function

- Provides a housing for gas lift valves within the tubing string.
- Positions gas lift valves at predetermined depths.
- Allows controlled gas injection into the tubing.
- Protects gas lift valves from mechanical damage.
- Facilitates gas lift system operation.
- Permits retrieval and replacement of valves without pulling tubing in side-pocket designs.
- Ensures proper alignment and performance of gas lift valves.

Working Principle

- The mandrel is installed as part of the tubing string during completion.
- It contains ports connecting the annulus to the tubing through a gas lift valve.
- Gas pressure in the annulus reaches the mandrel location.
- When the gas lift valve opens, gas flows through the mandrel ports.
- Gas enters the tubing and mixes with produced fluids.
- Side-pocket mandrels contain a special chamber where the valve is installed.
- Wireline tools can retrieve or replace valves through the side pocket.
- This reduces workover costs and minimizes production downtime.
- Mandrels ensure efficient and reliable gas lift performance.

6. Standing Valve

A standing valve is a one-way check valve located at the bottom of a sucker rod pump that allows fluid entry into the pump while preventing backflow.

Main Components

1. Valve Body

- Main housing structure.
- Supports all valve components**.**

2. Valve Cage

- Encloses the ball and seat assembly.
- Guides valve movement.

3. Ball

- Moves in response to pressure changes.
- Controls fluid entry.

4. Valve Seat

- Precision-machined sealing surface.
- Ensures leak-proof closure.

5. Ball Stop

- Restricts excessive ball movement.
- Maintains proper valve operation.

6. Threaded Connection

- Connects the standing valve to the pump assembly.

Figure 6: Standing Valve

Function

- Acts as a one-way valve in a sucker rod pumping system.
- Allows reservoir fluid to enter the pump barrel.
- Prevents fluid from flowing back into the formation.
- Improves volumetric efficiency of the pump.
- Maintains a fluid column within the pump.
- Supports continuous fluid lifting during pumping operations.
- Enhances overall pumping performance.

Working Principle

- The standing valve is installed at the bottom of the pump barrel.
- During the upstroke, pressure inside the pump decreases.
- The pressure difference causes the standing valve to open.
- Reservoir fluid enters the pump chamber through the valve.
- During the downstroke, pressure inside the pump increases.
- The standing valve closes automatically.
- Closure prevents fluid from returning to the reservoir.
- The trapped fluid is pushed upward through the pump system.
- Repeated pumping cycles progressively lift fluid to the surface.
- Efficient valve operation is essential for optimum pump performance.

7. Downhole Non-Return Valve (NRV)

A Downhole Non-Return Valve (NRV) is a one-way check valve installed in the tubing string to prevent reverse fluid flow.

Main Components

1. Valve Body

- Main housing of the NRV.
- Provides structural support.

2. Flapper/Ball/Disc

- Main moving element.
- Opens during forward flow.
- Closes during reverse flow.

3. Valve Seat

- Provides a sealing surface.
- Prevents leakage during closure.

4. Spring

- Assists closure in spring-loaded designs.
- Ensures rapid valve response.

5. Retainer

- Holds internal parts in proper position.

6. Flow Ports

- Allow passage of fluids during normal operation.

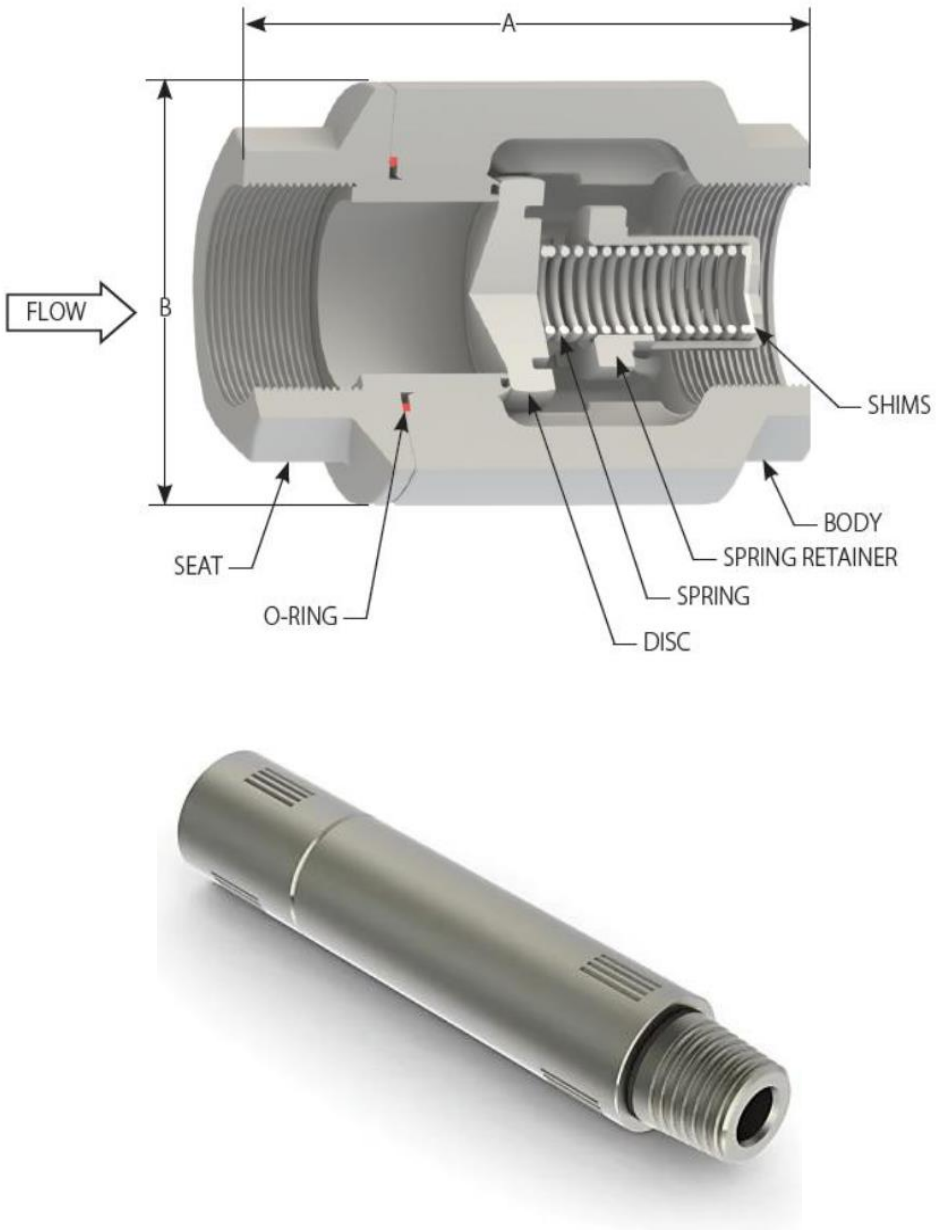

Figure 7 Downhole NRV

Function

- Prevents reverse flow of fluids within the tubing string.
- Protects downhole equipment from backpressure effects.
- Maintains one-way fluid movement toward the surface.
- Improves well control and operational safety.

- Protects pumps, gas lift valves, and completion equipment.
- Reduces the risk of pressure surges and fluid fallback.
- Maintains production system integrity during shutdowns.

Working Principle

- The NRV is installed within the tubing string at a selected depth.
- The valve contains a ball, flapper, or disc mechanism.
- During normal production, upward fluid pressure pushes the valve open.
- Fluids pass freely through the valve toward the surface.
- If pressure reverses, the valve mechanism immediately moves to the closed position.
- Reverse fluid flow is blocked automatically.
- The valve operates without external control or power.
- Opening and closing occur solely due to pressure differences.
- This automatic action protects the well and downhole equipment.
- NRVs are widely used in production, injection, gas lift, and artificial lift systems.